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Clean Up and Recovery (CURE) Wastewater Treatment System

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Clean Up and Recovery (CURE) Wastewater Treatment System

U.S. DEPARTMENT OF ENERGY
The Rocky Flats Environmental Technology Site
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM DIVISION

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1.0 INTRODUCTION/PURPOSE

Hydrologics, Inc. a subsidiary of General Environmental Corp., has the patent license for a unique Clean Up and Recovery (CURE) wastewater treatment system. CURE is an electrocoagulation process used for wastewater treatment. As ionic particles suspended in water combine with oppositely charged ions, they become stable and precipitate out of solution. Although this phenomenon is understood, the ability to process a continuous water flow through an electrogoagulation treatment system has been unattainable. However, CURES' unique patented configuration of the electrolytic process allows practical, continuous water flow through an electrocoagulation process. This process is efficient at removing heavy metals from wastewaters as well as breaking up oily emulsions, reducing suspended and dissolved solids, and removing dyes and some organic compounds.

The purpose of the testing performed in conjunction with EG&G Rocky Flats was to determine the effect CURE had on contaminated groundwater. Groundwater from the Rocky Flats Environmental Technology Site (RFETS), containing small amounts of radioactive and hazardous contaminants, was used for this experiment.

Preliminary tests were considered successful, and indicate that CURE is an effective process for the removal of radiological and heavy metal contamination in RFETS groundwater.

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2.0 EXPERIMENTAL

The experiments were performed at Accu-Labs, Inc., in Golden, Colorado. Water samples from Wells 09091 and 3086 were sent from RFETS to Accu-Labs, Inc. The two wells were chosen for their high uranium and plutonium content relative to other wells on plantsite. Hydrologics, Inc. provided the testing equipment.

The test equipment consisted of a peristaltic pump, electrocoagulation tubes, and a voltage/amp regulator. The tubes consisted of two concentric pipes that were approximately one foot in length. The system power supply applied a direct current (DC) across the two concentric tubes as the water flowed in the annular space. The current was controlled with a potentiometer.

The variable parameters during the test were: (1) the number of passes through a tube, (2) the tube material, and (3) the current. See Tables 2.0-1 for parameters and Table 2.0-2 for results.

Table 2.0-1 Parameters for Uranium/Plutonium Experiment

	Tube Passes		Volts		Amps			
Test Run Samples	Fe	Al	Fe	Al	Fe	Al	Water Volume per Run (L)	Flow Rate (mL/min)
1	0.0	3.0	0.0	5.0	0.0	5.0	2	750
2	3.0	0.0	7.0	0.0	7.0	0.0	2	750
3	3.0	2.0	6.9	4.5	6.9	4.5	2	750
4	3.0	2.0	8.7	5.8	8.7	5.8	2	750
5	3.0	2.0	4.9	3.6	4.9	3.6	2	750

The two well water samples were mixed equally (1:1) creating a mixed solution. The mixed solution was placed in a clean 1 Liter (L) beaker. It was then run through the CURE system in accordance with the parameters shown in Table 2.0-1. Once the sample had run through the system it was emptied into a second clean 1 L beaker. The water was allowed to stand in the second beaker for 10 to 20 minutes allowing the precipitates to aggregate into a number of fine suspended particles (i.e., floc). After the floc had formed, a stirrer was used to release the hydrogen gas buildup from water electrolysis and the floc settled to the bottom of the beaker; the solution was then run through a forty micron vacuum filter to remove the precipitate. The filtration process was repeated until the filtered liquid appeared clear. The filtered water was then placed in containers and preserved with nitric acid (HNO_3) for later analysis. The filter paper was disposed of in accordance with Accu-Labs, Inc. procedures.

Table 2.0-2 Results from Uranium/Plutonium Experiment

Test Run Samples	Utotal* pCi/L	Pu-239, 240** pCi/L	% Removed Utotal	% Removed Pu-239, 240
Head Sample	31.0	13.00	—	—
1	0.7	0.04	97.7	99.7
2	28.3	0.09	8.6	99.3
3	0.6	0.03	98.0	99.8
4	0.2	0.01	99.4	99.9
5	1.6	0.00	95.0	100.0
Legend: *Potential ARAR for U = 5 pCi/L **Potential ARAR for Pu = .05 pCi/L				

The same test procedure was used on a water sample from Well B206789 to test the ability of the CURE technology to remove selenium from RFETS groundwater. Parameters and results are shown in Tables 2.0-3 and 2.0-4.

Table 2.0-3 Parameters from Selenium Experiment

Test Run Samples	Tube Passes		Volts		Amps		Water Volume per Run (L)	Flow Rate (mL/min)
	Fe	Al	Fe	Al	Fe	Al		
1	3.0	2.0	9.0	20.0	7.5	7.5	700	750
2	3.0	2.0	9.0	20.0	9.0	9.0	700	750
3	0.0	2.0	—	16.0	—	9.0	300	750

Table 2.0-4 Results from Selenium Experiment

Test Run Samples	Selenium* ug/L	% Removed
Head Sample	600.0	—
1	190.0	68.3
2	86.0	85.7
3	45.0	92.5
Legend: *Potential ARAR for Selenium = 10 ug/L		

3.0 INTERPRETATION/CONCLUSION OF TESTING

The results of the RFETS groundwater testing demonstrated CURE's high removal percentage of uranium and plutonium (above 90 percent in all cases except one). Uranium and plutonium fell below their potential applicable or relevant and appropriate requirements (ARARs) of 5 pCi/L and .05 pCi/L, respectively. Selenium also had a high removal percentage ranging from 68 to 92 percent. Because of the high selenium content of the groundwater (i.e., 600 μg/L) levels did not fall below the potential ARAR of 10 μg/L. Further optimization of the CURE process will allow for selenium removal to fall below its potential ARAR.

The early results indicated that three passes through the iron tube followed by two passes through the aluminum tube at 7.5 amps and 8.7 and 5.8 volts, respectively, yielded the best results for radionuclides. The results of this experiment are shown in Table 2.0-2. Selenium experiments indicated that two passes through the aluminum tube with 9.0 amps and 16.0 volts had the highest removal rate. Results for selenium removal are shown in Table 2.0-4.

Optimization runs were not attempted and, therefore, the test results are only an indicator of CURE's removal capacity.

A review of the results indicated the radionuclides required the iron and aluminum tubes for the treatment process. Tests on the selenium water sample indicated that a solitary aluminum tube pass as well as the aluminum/iron combination had a removal effect. Selenium required higher voltage in the aluminum tube and slightly more amperage than the radionuclides for the same removal percentages. However, the radionuclides did follow a trend towards higher removal rates with higher voltages. Therefore, the high voltage required for selenium may not produce an adverse effect for radionuclides.

It is important to note that not all possible parameters were tested. Future testing may find water pH and water temperature to be important factors. These factors have affected other types of water treatment systems and might affect the CURE process.

4.0 OPERATING SYSTEM

The design for an operating CURE processing unit would be similar to other water treatment facilities. Feed lines bring water from the source(s) to the process pumps. The pumps force the water through the CURE tubes for coagulation. Next, the water flows into a separation system (a separation tank or clarifier) for separation and removal of the precipitates. Finally, the water passes through any necessary pH adjustment tanks and exited as treated water.

Figures 4.0-1 and 4.0-2 model The CURE wastewater treatment system which can be sized to handle a continuous flow rate of fifty gallons per minute with the parameters of run 4 in the experiment.

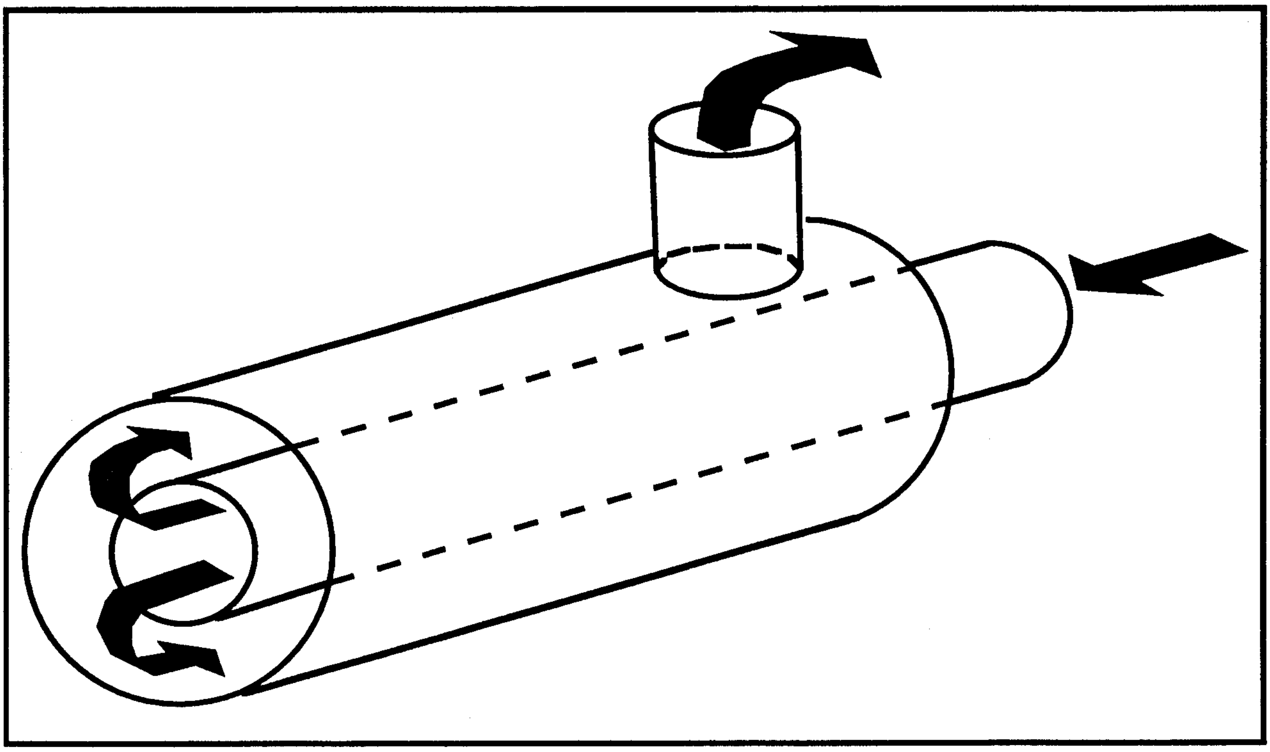

Figure 4.0-1 CURE Concentric Tubing

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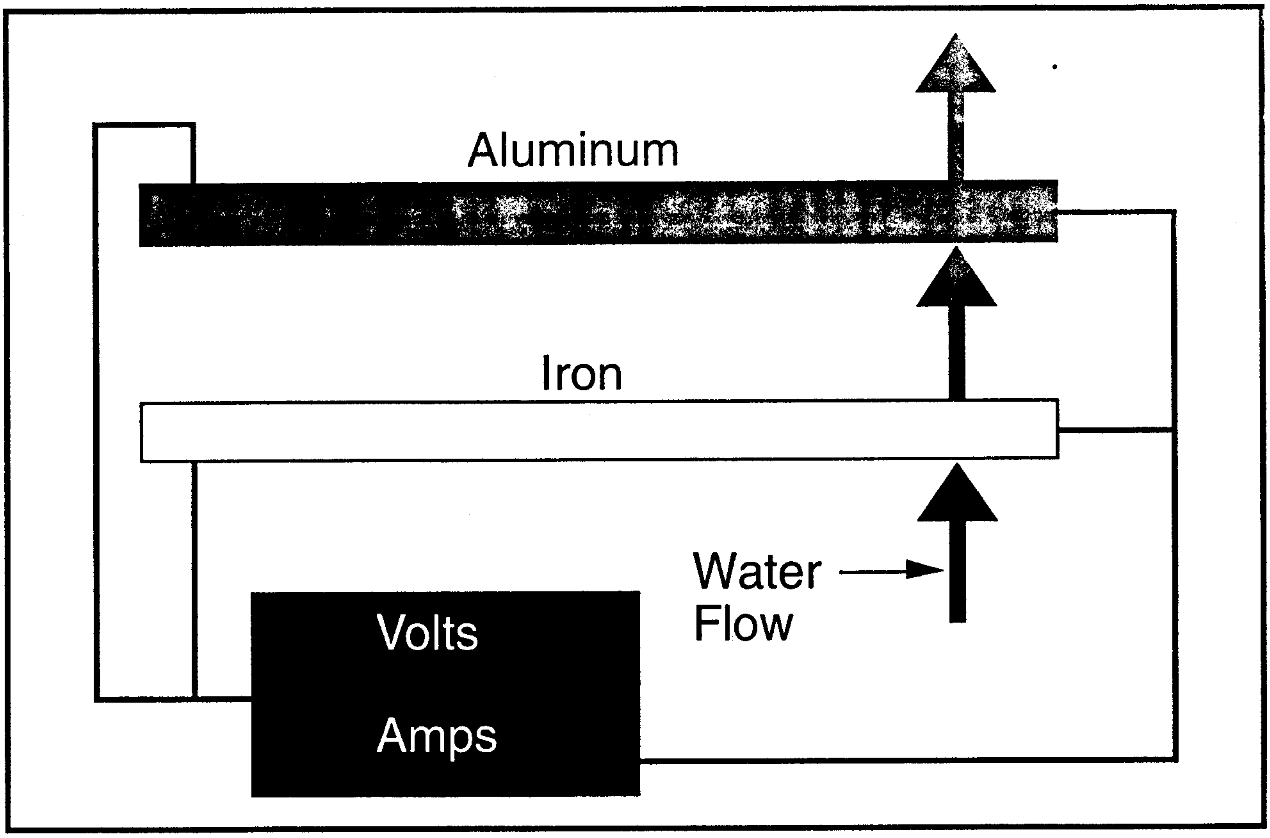

Figure 4.0-2 CURE Flow Diagram

The system consists of:

- Influent Tank
- Skid Mounted CURE System
  - Power Supply
  - Control Panel
  - Process Pump
  - Electrocoagulation Tubes, with Redundant Set
  - Instrumentation
- Clarifier
- Sludge Dewatering Equipment (i.e., Filter Process)

The system was designed with automated and manual emergency shut-down and re-start. In an emergency, the process bypassed the low back to the influent tank until the treatment was under normal operation, thereby, allowing the water to go on to the clarifier. In the shut-down mode, the system automatically rinsed the tubes. This kept the system from plugging during non-operational times. During normal operation, the system alerted the operator when it was necessary to change the spent reactor tubes and clean the filter press.

5.0 CAPITAL COST ESTIMATE

The purchase cost for the fifty gallon per minute system is approximately $252,500.00. Installation costs have not been included.

5.1 OPERATING COST ESTIMATE

Projected operating cost are $1.70 for every 1,000 gallons treated. This cost is for a system using 480 Volts, 3 Phase power at $0.07 per kilowatt hour. Estimated operating time for the system is 20 hours per day, 7 days a week. Additional operating costs will consist of the technician(s) monitoring the unit, cost of replacement pipes, power to the unit and pumps, and disposal of waste.

6.0 CONCLUSION

As described in Section 3.0, the results of the RFETS groundwater testing demonstrated CURE's high removal percentage of uranium and plutonium (above 90 percent in all cases except one). Uranium and plutonium fell below their potential applicable or relevant and appropriate requirements (ARARs) of 5 pCi/L and .05 pCi/L, respectively. Selenium also had a high removal percentage ranging from 68 to 92 percent. Because of the high selenium content of the groundwater (i.e., 600 µg/L) levels did not fall below the potential ARAR of 10 µg/L. Further optimization of the CURE process will allow for selenium removal to fall below its potential ARAR.

This process can be optimized for the removal of radionuclide and selenium in waters at RFETS with a flowrate of approximately fifty gallons per minute.

Appendix A

Acronym List

ARAR	Applicable or Relevant and Appropriate Requirement
CURE	Clean Up and Recover
RFETS	Rocky Flats Environmental Technology Site
DC	Direct Current
L	Liter
HNO_3	Nitric Acid
pH	Hydrogen Ion Concentration log [H+]